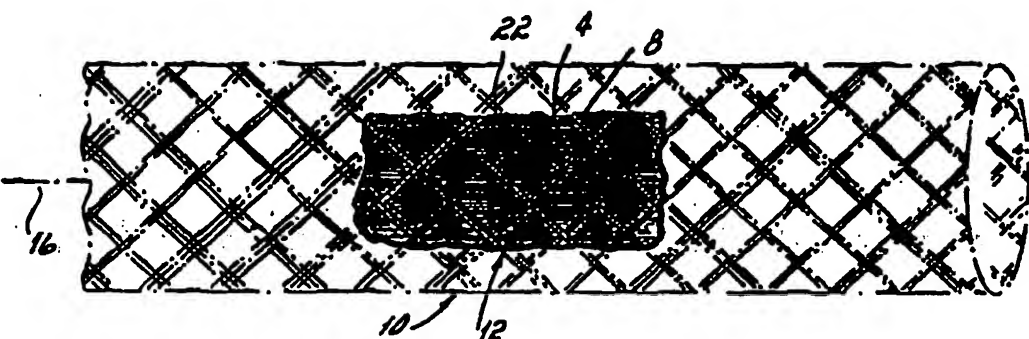




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>B29D 23/00, D04C 1/02; 1/04</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 98/24616</b> <b>(43) International Publication Date:</b> 11 June 1998 (11.06.98)												
<b>(21) International Application Number:</b> PCT/US97/21800 <b>(22) International Filing Date:</b> 1 December 1997 (01.12.97)  <b>(30) Priority Data:</b> <table border="0"><tr><td>08/759,255</td><td>2 December 1996 (02.12.96)</td><td>US</td></tr><tr><td>60/032,230</td><td>2 December 1996 (02.12.96)</td><td>US</td></tr><tr><td>08/759,732</td><td>6 December 1996 (06.12.96)</td><td>US</td></tr><tr><td>08/942,908</td><td>2 October 1997 (02.10.97)</td><td>US</td></tr></table> <b>(71) Applicant:</b> A & P TECHNOLOGY, INC. [US/US]; Two Braid Way, Covington, KY 41017-9702 (US). <b>(72) Inventor:</b> HEAD, Andrew, A.; 5055 Burley Hills Drive, Indian Hill, OH 45243 (US). <b>(74) Agents:</b> MURTAUGH, John, P. et al.; Pearne, Gordon, McCoy & Granger LLP, 1200 Leader Building, Cleveland, OH 44114-1401 (US).		08/759,255	2 December 1996 (02.12.96)	US	60/032,230	2 December 1996 (02.12.96)	US	08/759,732	6 December 1996 (06.12.96)	US	08/942,908	2 October 1997 (02.10.97)	US	<b>(81) Designated States:</b> CA, DE, GB, JP, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
08/759,255	2 December 1996 (02.12.96)	US												
60/032,230	2 December 1996 (02.12.96)	US												
08/759,732	6 December 1996 (06.12.96)	US												
08/942,908	2 October 1997 (02.10.97)	US												
<b>(54) Title:</b> BRAIDED STRUCTURE WITH ELASTIC BIAS STRANDS														
														
<b>(57) Abstract</b>  A triaxial braided sleeve (10) in which the axial strands (22) are reinforcing and the bias strands (4 and 8) are elastic. Due to the elastic bias strands (4 and 8), the sleeve (10) can be used as the reinforcement in a fiber-reinforced plastic part having a tapered, curved, or other irregular shape.														

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BRAIDED STRUCTURE WITH ELASTIC BIAS STRANDS

This application is a continuation-in-part of (1) United States Patent Application Serial No. 08/759,255, filed December 2, 1996 and (2) United States Patent Application Serial No. 08/759,732, filed December 6, 1996. This application claims the benefit of United States Provisional Patent Application Serial No. 60/032,230, filed December 2, 1996.

FIELD OF THE INVENTION

This invention relates generally to braided structures and more particularly to braided structures having elastic bias strands or filaments.

DESCRIPTION OF RELATED ART

It is known to use braided sleeving to form rigid tubular parts such as fiber-reinforced plastic parts. The braided sleeving is typically impregnated with a resin and placed in or over a mold or mandrel or core and subjected to heat and pressure to form or cure the resin and form the tubular part. See U.S. Pat. Nos. 5,409,651 and 4,774,043, the contents of which are incorporated by reference.

Biaxial and triaxial braided sleeving is known. Triaxial braided sleeving is preferable to biaxial braided sleeving in many situations because triaxial sleeving generally produces a finished part which has superior mechanical properties, principally strength and stiffness.

A problem with triaxial braided sleeving is that it has little stretchability 1) longitudinally and 2) transversely to the longitudinal axis of the sleeve. On the other hand, biaxial braided sleeving is generally stretchable both longitudinally and transversely

1 (radially). If expanded longitudinally, a biaxial braid  
2 will contract radially; if expanded radially, it will  
3 contract longitudinally. This permits biaxial braided  
4 sleeving to be utilized to form tubular parts having  
5 varying cross-sections, i.e. alternatively smaller and  
6 larger cross-sections or diameters.

7 There is a need for a triaxial braided sleeving which  
8 has the ability to conform to a tubular shape having  
9 varying cross-sections. There is also a need for a fiber-  
10 reinforced plastic part made from such sleeving.

#### 11 SUMMARY OF THE INVENTION

12  
13  
14 A triaxial braided sleeve is provided, comprising  
15 first bias strands extending in a first helical direction,  
16 second bias strands extending in a second helical direction  
17 different from said first helical direction, and axial  
18 reinforcement strands, said first bias strands, second bias  
19 strands and axial reinforcement strands being braided  
20 together to form a triaxial braided sleeve, all of the bias  
21 strands of the sleeve being elastic strands. A method of  
22 making the triaxial braided sleeve is also provided, along  
23 with fiber-reinforced plastic parts made utilizing the  
24 invented triaxial braided sleeve.

#### 25 BRIEF DESCRIPTION OF THE DRAWINGS

26  
27  
28 Fig. 1A is a schematic view of a portion of a prior  
29 art bi-axial braided sleeve.

30 Fig. 1B is a schematic view of a portion of a prior  
31 art triaxial braided sleeve.

32 Fig. 1 is a side schematic view of a portion of a  
33 triaxial braided sleeve in accordance with the present  
34 invention, with a portion shown in more detail.

35 Fig. 2 is a side elevational view of a mandrel in the

1 shape of an article of manufacture to be formed, for  
2 example a rifle scope.

3 Fig. 3A is a fragmentary side view of the sleeve of  
4 Fig. 1 being placed over the mandrel of Fig. 2.

5 Fig. 3B is a side elevational view of the sleeve of  
6 Fig. 1 placed over the mandrel of Fig. 2.

7 Fig. 4 is a side elevational view of the finished part  
8 manufactured according to the process of the present  
9 invention.

10 Fig. 5 is a plan view of a portion of a triaxial  
11 braided sleeve in accordance with the present invention.

12 Fig. 6 is a side elevational view of a utility pole.

13 DETAILED DESCRIPTION OF THE  
14 PREFERRED EMBODIMENTS OF THE INVENTION

15  
16 As used in the specification and claims herein, the  
17 term "strand" includes a single fiber or filament or thread  
18 as well as a bundle of fibers or filaments or threads.  
19 Each of the following, whether twisted or untwisted, is a  
20 strand: a fiber, a filament, a yarn, a tow, and a thread.

21 As used in the claims herein, "elastic" means capable of  
22 being stretched repeatedly at room temperature to at least  
23 about 1.4 times its original length and which, after  
24 removal of the tensile force, will immediately return to  
25 approximately its original length. "At least 1.4 times its  
26 original length" means if the original length is 1 inch, it  
27 can be stretched to a total length of at least 1.4 inches,  
28 and after release it will return to approximately 1 inch.

29 With reference to Fig. 1A, there is shown a portion of  
30 a known biaxial braided sleeve which is tubular. It is  
31 formed of strands which are braided together. As known in  
32 the art, a biaxial braided sleeve has two sets of helical  
33 bias strands 14, 18. All of a plurality of first bias  
34 strands 14 extend in one direction 13 parallel to one  
35 another at an angle alpha to the longitudinal axis 16 of

1 the sleeve. Angle alpha is the braid angle of the bias  
2 strands 14; the braid angle is the acute angle measured  
3 from the longitudinal braid axis to the bias strand. All  
4 of a plurality of second bias strands 18 extend in a second  
5 direction 15 parallel to one another at an angle beta to  
6 the longitudinal axis 16. Normally the angles alpha and  
7 beta are the same and in that case either one can be used  
8 to describe the braid angle.

9 Diamond braid is a known braid style, in which the  
10 bias strands are braided in an over one, under one  
11 configuration. In a style known as regular braid, the bias  
12 strands are braided in an over two, under two  
13 configuration. Regular braid and diamond braid are the  
14 most common braiding styles and are well-known in the art.  
15 Less common are the hercules braid (over three, under  
16 three) and various satin braids. Any of these braiding  
17 styles can be used in Fig. 1A.

18 Fig. 1B illustrates a portion of a known triaxial  
19 braided sleeve. A triaxial braid has bias strands  
20 identical to the bias strands 14, 18 in Fig. 1A, which can  
21 be diamond braided, regular braided, etc. The triaxial  
22 braid in addition has a plurality of axial strands 20  
23 extending parallel to the longitudinal axis of the sleeve.  
24 Axial strands are sometimes referred to as warps or  
25 unidirectionals or laid-in strands or tows or yarns. The  
26 axial strands are interwoven with the bias strands, with  
27 the bias strands passing over and under the axial strands  
28 as is known in the art. The number of axial strands can be  
29 varied, and preferably they are spaced equidistantly or  
30 regularly or uniformly around the perimeter of the sleeve,  
31 as is shown in Fig. 1B. Uniform spacing provides for  
32 uniform strength across the braid fabric.

33 With reference to Fig. 1, there is shown a triaxial  
34 braided sleeve 10 according to the present invention. A  
35 portion 12 of sleeve 10 is shown in greater detail. Sleeve

1 10 has a series of elastic bias strands 4 extending in one  
2 helical direction, a second series of elastic bias strands  
3 8 extending in the other helical direction, and a plurality  
4 of axial strands 22 extending parallel to the longitudinal  
5 axis of the sleeve. Fig. 1 shows some bias strands 4, 8 as  
6 double strands; preferably each bias strand is a single  
7 thread. In the present invention a triaxial braided  
8 sleeving or sleeve is provided in which all of the bias  
9 strands are elastic and preferably all of the axial strands  
10 are structural or reinforcing such as reinforcing tows; the  
11 axial strands are present to provide strength and stiffness  
12 and they are inelastic or nonelastic or essentially  
13 inelastic or non-stretchable and are preferably non-heat-  
14 shrinkable.

15 In the present invention it is preferable to maximize  
16 the amount or percentage of braid fabric or fiber material  
17 or strand material in the axial direction and minimize the  
18 amount or percentage of braid fabric or strand material in  
19 the bias direction, because the purpose of the bias strands  
20 is only to hold or maintain the axial strands in position  
21 and be elastic; the bias strands are not there to provide  
22 appreciable strength or stiffness. As long as sufficient  
23 bias strands are present to perform their function,  
24 additional bias strands would be wasteful. Therefore it is  
25 preferable to minimize the number of bias strands and  
26 minimize the weight and thickness of each bias strand. It  
27 is desired to maximize the percentage of axial strand  
28 material, which provides the strength and stiffness of the  
29 braid.

30 With reference to Fig. 5, there is shown a portion 40  
31 of a triaxial braided sleeve of the present invention,  
32 having first bias strands 42 extending in a first helical  
33 direction, second bias strands 44 extending in a second  
34 helical direction, and axial reinforcement strands or tows  
35 46 (such as 12K carbon) extending parallel to the

1 longitudinal axis of the sleeve.

2       The axial strands or reinforcement strands are  
3 preferably fiberglass, carbon or aramid (Kevlar), less  
4 preferably ceramic, ultrahigh molecular weight polyethylene  
5 (such as Spectra brand), other synthetics such as acrylic,  
6 nylon, rayon, polypropylene, polyamide, and polyester,  
7 natural fibers such as cotton, PTFE, metals, thermoplastic  
8 yarn, and mixtures or hybrids thereof, such as  
9 fiberglass/carbon. The fiberglass strands or tows are  
10 preferably E-glass (texturized or non-texturized) or S-  
11 glass (such as S-2 glass), as known in the art, preferably  
12 37 to 1800 yield, more preferably 450 to 1200 yield,  
13 commonly 112, 450, 827, 1200 and 1800 yield. These are  
14 known in the art and are available from Owens Corning  
15 Fiberglass and PPG, such as PPG's 2002-827 Hybon and Owens  
16 Corning's Product No. 111A 275. The carbon strands or tows  
17 are preferably 3K, 6K, 12K and 48K, both commercial grade  
18 and aerospace grade, available from Hexcel, Toho, Toray,  
19 Amoco, and Grafil, including AS4 carbon and Hexcel Product  
20 No. IM7-GP12K. The aramid strands or tows are preferably  
21 Kevlar brand from DuPont, Kevlar 29 and Kevlar 49,  
22 preferably 200 to 1500 denier, such as 200, 380, 1140,  
23 1420, and 1500 denier. These strands can have sizing, such  
24 as Nos. 964 or 965 as known in the art. These structural  
25 or reinforcement strands typically have 1-6% strain to  
26 failure (ASTM D2101), meaning they will stretch 1-6% and  
27 then break; as can be seen they are essentially inelastic.  
28 With reference to Fig. 5, the axial strands 46 are  
29 preferably all the same, less preferably they can vary,  
30 such as every fifth one or every other one being carbon and  
31 the rest fiberglass, or the strands on one side of the  
32 sleeve being heavy fiberglass and the strands on the other  
33 side of the sleeve being lighter fiberglass.

34       The elastic bias strands are preferably elastic  
35 threads or elastic yarns as known in the art. An elastic



1 thread typically has a core of an elastomer such as natural  
2 or synthetic rubber or similar elastomer or spandex and may  
3 or may not have a cover or serving of natural or synthetic  
4 fibers or fabric, typically cotton, nylon or polyester. If  
5 the elastic thread is uncovered, it preferably will stretch  
6 at least 200, 400, 500, 600 or 700%; it preferably will  
7 have 100-800%, more preferably 400-800%, maximum stretch or  
8 elongation at break. If a one inch thread has 700% maximum  
9 stretch, that means it will stretch at room temperature to  
10 eight inches and then break or fail; since it is elastic it  
11 will return to approximately one inch length if released  
12 before breakage. If the elastomer or rubber or spandex  
13 core is covered, the elastic thread preferably has at least  
14 70, 100, 200, or 300%, or about 100-150%, 100-200%, or 100-  
15 400%, maximum stretch or elongation at break; if a one inch  
16 thread has 130% maximum stretch, that means that it will  
17 stretch to a maximum of 2.3 inches before failing or  
18 tearing the cover. The cover acts to control or limit the  
19 stretch (which may make braiding easier), imparts  
20 additional tensile strength, and frequently makes the  
21 thread slipperier; covered thread is preferred where these  
22 characteristics are useful.

23 The elastic thread has a maximum stretch of at least  
24 40%, more preferably at least 75%, more preferably at least  
25 about 90%, more preferably at least 100%, typically at  
26 least 100, 200, or 300%, or about 100-200, 100-400, or 100-  
27 800, % maximum stretch. The elastic thread preferably has  
28 a weight of 250 to 6000, more preferably 700-4400, yds/lb.  
29 Suitable elastic threads for use in the present invention  
30 include No. SE144 (rubber core with nylon cover, 785  
31 yds/lb., having 130% max. stretch), uncovered Lycra brand  
32 spandex having 700% max. stretch, 560-650 denier, and No.  
33 135A9J (Lycra brand spandex core with polyester cover, 4200  
34 yds/lb., having 120% max. stretch), available from Supreme  
35 Corp., Hickory, N.C.

1       The present invention is made on conventional braiding  
2 machines or braiders having 8 to 800 or more carriers,  
3 typically having 80 to 400 or 500 or 600 carriers, for  
4 example 144 or 208 carriers, although braiders with 16 to  
5 80 carriers are useful for smaller sleeves such as for a  
6 golf club shaft. A conventional 144 carrier braider has 72  
7 axial positions. As known in the art, a conventional  
8 braider has one axial position for every two carriers. In  
9 producing the invented braid preferably all of the axial  
10 positions on the braider are used, in order to maximize the  
11 percentage of the braid fabric in the axial position or  
12 direction. Less preferably, less than all the axial  
13 positions are utilized.

14       When a conventional 144 carrier braider is run  
15 utilizing all 144 carriers and all 72 axial positions, a  
16 regular braid is produced having 72 bias strands extending  
17 in one bias direction, 72 bias strands extending in the  
18 other bias direction, and 72 axial strands running  
19 longitudinally. When that 144 carrier braider is run  
20 utilizing only 72 of the carriers (36 in one bias direction  
21 and 36 in the other bias direction), a diamond braid is  
22 produced. When that 144 carrier braider is run utilizing  
23 only 36 of the carriers (18 in one bias direction and 18 in  
24 the other bias direction), a braid referred to herein as a  
25 double diamond braid is produced. When that 144 carrier  
26 braider is run utilizing only 18 of the carriers (9 in one  
27 bias direction and 9 in the other bias direction), a braid  
28 referred to herein as a triple diamond braid is produced.  
29 Regular, diamond, double diamond, and triple diamond braids  
30 can be produced on braiders having other numbers of  
31 carriers (eg., 80 carriers, 208 carriers, 400 carriers) by  
32 using the same ratios. As used in the specification and  
33 claims herein, diamond, double diamond, and triple diamond  
34 shall have the meanings as described above.

35       The invented braid is preferably made on a regular

1 braider (a braider which makes regular braid when its full  
2 compliment of carriers are utilized) utilizing  $1/2$  to about  
3  $1/75$ , more preferably  $1/2$  to about  $1/60$ , more preferably  
4 about  $1/4$  to about  $1/40$ , more preferably about  $1/8$  to about  
5  $1/20$ , alternatively about  $1/12$  to about  $1/16$ , of the full  
6 compliment of carriers, preferably not more than  $1/2$  or  $1/4$   
7 or  $1/8$  or  $1/12$  or  $1/16$ , and preferably not less than  $1/75$   
8 or  $1/60$  or  $1/40$  or  $1/20$ , of the full compliment of  
9 carriers, subject to the condition that the carriers  
10 utilized are equally spaced and symmetrically arrayed with  
11 an equal number of carriers going in each direction. For  
12 example, a 600 carrier braider could utilize  $1/60$ , or ten  
13 carriers, with five going in each direction and  
14 symmetrically arrayed. Regarding the invented braid, a  
15 triple diamond braid is preferable to a double diamond  
16 braid, which is preferable to a diamond braid.

17 As used in the specification and claims herein, an  
18 "axial position strand" is all of the fibers or filaments  
19 or strands or threads or tows going through one axial  
20 position on a braider, and a "bias carrier strand" is all  
21 of the fibers or filaments or strands or threads or tows on  
22 a single carrier of a braider. In the present invention  
23 each axial position strand will typically be one or two or  
24 three or four tows of reinforcing filaments and each bias  
25 carrier strand will typically be one elastic thread. In  
26 the invented braid the ratio of axial position strands to  
27 bias carrier strands (including, by definition, those bias  
28 strands going one way and those bias strands going the  
29 other way) is preferably at least 1:1, more preferably at  
30 least 2:1, more preferably at least 4:1, more preferably at  
31 least 6:1, alternatively at least 8:1 or 10:1 or 20:1 or  
32 30:1, preferably not more than 37.5:1 or 30:1,  
33 alternatively not more than 20:1 or 10:1 or 8:1. For  
34 example, a 600 carrier braider using ten carriers and 300  
35 axial positions produces a braid having a ratio of axial

1 position strands to bias carrier strands of 300:10 or 30:1.  
2 Preferably, whenever less than all the carriers or axial  
3 positions are used, those that are used are spaced as  
4 evenly or equidistantly or uniformly around the braider as  
5 possible.

6 As an option, a portion of the axial positions can be  
7 one reinforcing strand and the other portion of the axial  
8 positions can be a different weight or type of reinforcing  
9 strand; for example on a snowboard it may be desirable to  
10 have more reinforcing on the bottom than on the top. This  
11 is achieved by loading thicker, heavier fiberglass on the  
12 axial positions around one half of the braider deck and  
13 loading a lighter fiberglass or carbon, etc. on the axial  
14 positions around the other half of the braider deck. The  
15 resulting sleeve would have a bottom half (for the bottom  
16 of the snowboard) heavily reinforced with fiberglass and a  
17 top half (for the top half of the snowboard) with less  
18 fiberglass reinforcing or alternatively lighter carbon or  
19 aramid reinforcing. These same principles can be applied  
20 to produce differentially or asymmetrically reinforced  
21 sleeving for other products such as curves in furniture,  
22 different sides of hockey sticks, different sides of snow  
23 skis, etc. A side facing or experiencing more stress may  
24 be more heavily reinforced. Stated more generally, the  
25 braided sleeve would have a first axial position strand of  
26 a first material and a second axial position strand of a  
27 second material, the first material being different from  
28 the second material in type (for example, one is fiberglass  
29 and the other is carbon or fiberglass/carbon) or weight  
30 (for example, one is 112 yield fiberglass and the other is  
31 827 yield fiberglass). Preferably, at least 10%, more  
32 preferably 20%, more preferably 30%, more preferably 40%,  
33 more preferably 45%, more preferably about 50%, of the  
34 axial position strands are of the first material, with the  
35 remaining axial position strands being of the second

1 material; optionally some of the remaining axial position  
2 strands can be of a third material, a fourth material, etc;  
3 preferably at least 10%, more preferably 20%, more  
4 preferably 30%, more preferably 40%, more preferably 45%,  
5 more preferably about 50%, of the axial position strands  
6 are of the second material.

7 When the braider is set up to produce the invented  
8 braid, elastic strands are loaded onto the carriers being  
9 utilized (preferably one end or thread per carrier, less  
10 preferably more than one end or thread per carrier) and set  
11 at light to medium spring tension. Reinforcement strands  
12 (such as 112 or 450 yield E-glass or 12K carbon) are placed  
13 in the axial positions, typically one, two, three, or four  
14 ends per position (although up to about 8 ends per position  
15 can be used). The amount of reinforcement strands is  
16 generally a function of the amount of reinforcing needed in  
17 the finished part, which is generally known in the art.  
18 Preferably the reinforcement axial strands are run from  
19 supplier packages under the machine rather than from  
20 spools. The axial strands are set to very light to no  
21 tension. The machine is then set to produce a braid angle  
22 of 35-75°, more preferably 45-75°, more preferably 40-70°,  
23 more preferably 45-65°, more preferably 50-63°, more  
24 preferably 55-60°, typically 57° or 60°.

25 It is preferred to minimize the weight percent of the  
26 braided fabric which is elastic strands; preferably elastic  
27 strands make up 0.1-20 (or more), more preferably 0.5-15,  
28 more preferably 1-10, more preferably 2-6, preferably less  
29 than 20, more preferably less than 10, more preferably less  
30 than 7.5, more preferably less than 5, more preferably less  
31 than 3, weight percent of the braided fabric, with the  
32 balance being reinforcement strands. The invented braided  
33 sleeve, in its relaxed state, is preferably about 0.01-24,  
34 more preferably about 0.1-8, more preferably about 0.5-5,  
35 inches in diameter.

1       The braid produced can then be used to produce fiber-  
2 reinforced plastic parts as are well-known in the art. The  
3 braided sleeving can be impregnated with a resin (such as  
4 epoxy, polyester, vinyl ester, polyurethane, phenolic,  
5 nylon, acrylic, and other thermosets or thermoplastics) and  
6 placed in or over a mold or substrate or base form or core  
7 or mandrel and subjected to heat and/or pressure to form or  
8 cure the resin and form the part. The processes that can  
9 be utilized include resin transfer molding (RTM) and Srimp  
10 brand molding, hand lay-up, compression molding, pultrusion  
11 molding, "B stage" forming, and autoclave molding, all as  
12 known in the art. The resins and molding techniques that  
13 can be used to make reinforced plastic parts using the  
14 invented braided sleeving are well-known in the art and  
15 are, for example, described and referred to in U.S. Pat.  
16 Nos. 5,419,231; 5,409,651; 4,283,446; 5,100,713; 4,946,721;  
17 and 4,774,043 and the U.S. patents mentioned in those  
18 patents, the disclosures of all of which are incorporated  
19 herein by reference.

20       Figs. 2-4 illustrate a method of manufacturing an  
21 article incorporating the sleeve of Fig. 1. Fig. 2  
22 illustrates a mandrel 24 generally in the shape of the  
23 article to be formed, for example, a tube scope to be  
24 mounted on a firearm. The mandrel 24 has two end sections  
25 26, 28 of a relatively large diameter and a middle narrow  
26 section 30 having a much smaller diameter. In the middle  
27 of the middle section 30 is an annular enlargement 32 of a  
28 larger diameter than the remainder of middle section 30 but  
29 of a smaller diameter than the end sections 26, 28.  
30 Although one specific mandrel having cross-sections of  
31 differing diameters is illustrated, many variations thereof  
32 may be used to form many different shaped parts.

33       Fig. 3A illustrates the sleeve of Fig. 1 being placed  
34 over the mandrel of Fig. 2 from left to right in the  
35 direction of arrows 34. Due to the elastic bias strands of

1 braided sleeve 10, the sleeve may be radially expanded over  
2 the different portions of the mandrel and maintain a snug  
3 fit throughout the entire length of the mandrel, and  
4 maintain the axial strands 22 equidistantly or equally or  
5 uniformly spaced around the perimeter of the various cross-  
6 sections of the mandrel, thus providing more uniform  
7 strength across the finished part. The invented axial  
8 reinforcing sleeve can be stretched over tapered, curved,  
9 or other irregular shapes, distributing the axial  
10 reinforcements uniformly around the perimeter of the part.  
11 The relaxed diameter of the sleeve is selected so that it  
12 is no larger than the narrowest diameter of the mandrel.  
13 When the sleeve is stretched over the mandrel or core or  
14 form or substrate, preferably its final stretched state is  
15 not more than 50, less preferably 75, less preferably 100,  
16 less preferably 200, percent more than its relaxed state,  
17 since greater stretching more greatly separates the axial  
18 strands, resulting in less strength and stiffness, although  
19 the sleeve can in less critical applications be stretched  
20 up to 700 and 800 percent and more. The sleeve is  
21 particularly effective for cores or mandrels whose greatest  
22 cross-sectional perimeter (perimeter at the cross section)  
23 is not more than 50, less preferably 75, less preferably  
24 100, less preferably 200, percent more than its least  
25 cross-sectional perimeter, for the reason set forth above.  
26 As can be seen in Fig. 3B, the sleeve covers the entire  
27 length of the mandrel.

28 At some point in the process the sleeve is  
29 preimpregnated ("prepreg"), impregnated or covered or  
30 coated with resin and the part is then cured or formed,  
31 typically via application of heat and/or pressure, all as  
32 known in the art previously described. The part is cooled  
33 and the mandrel is typically removed. Alternatively a  
34 substrate or form (such as a polyurethane foam core or  
35 other foam core) is used which functions as a mandrel but

1 is not removed and becomes part of the finished article;  
2 this is also known in the fiber-reinforced plastic art.  
3 The resulting tubular article 36 is shown in Fig. 4. Fig.  
4 6 shows a tapered hollow utility pole or tube 48 made in a  
5 similar manner.

6 Fiber-reinforced plastic parts known in the art having  
7 varying cross sections can be advantageously made using the  
8 present invention, including golf club shafts, lighting  
9 poles, hollow utility poles or tubes, pipes, tubing with  
10 bends and diameter changes, ducting for aircraft such as  
11 air conditioning ducting, electric transmission poles, ski  
12 poles, fishing rods or poles, flag poles, push poles for  
13 boats (tapered at each end), bicycle parts, including  
14 seats, wheels and frames, hockey sticks, field hockey  
15 sticks, snowboards, wakeboards, snow skis, water skis,  
16 firearm (such as rifle) scopes, tapered poles, tapered bars  
17 or rods, connectors for tubing, and parts having complex  
18 shapes like parts of a chair or commercial furniture such  
19 as the corners or bends.

20 Although the preferred embodiments of this invention  
21 have been shown and described, it should be understood that  
22 various modifications and rearrangements of the parts may  
23 be resorted to without departing from the scope of the  
24 invention as disclosed and claimed herein.



## WHAT IS CLAIMED IS:

1           1.    A triaxial braided sleeve comprising first bias  
2 strands extending in a first helical direction, second bias  
3 strands extending in a second helical direction different  
4 from said first helical direction, and axial reinforcement  
5 strands, said first bias strands, second bias strands and  
6 axial reinforcement strands being braided together to form  
7 a triaxial braided sleeve, all of the bias strands of the  
8 sleeve being elastic strands.

1           2.    A sleeve according to claim 1, wherein each of  
2 said axial reinforcement strands is of a material selected  
3 from the group consisting of fiberglass, carbon, aramid,  
4 and mixtures or hybrids thereof.

1           3.    A sleeve according to claim 1, wherein each bias  
2 strand of said sleeve is an elastic thread.

1           4.    A sleeve according to claim 1, said sleeve being  
2 not more than 7 weight percent bias strands and the  
3 remaining weight percent being axial reinforcement strands.

1           5.    A sleeve according to claim 1, said sleeve having  
2 been produced on a regular braider utilizing not more than  
3 1/4 of the full compliment of carriers of said regular  
4 braider.

1           6.    A sleeve according to claim 1, said sleeve having  
2 been produced on a regular braider utilizing not more than  
3 1/8 of the full compliment of carriers of said regular  
4 braider.

1           7.    A sleeve according to claim 1, said sleeve having  
2 a ratio of axial position strands to bias carrier strands  
3 of at least 2:1.

1           8. A sleeve according to claim 1, said sleeve having  
2 a ratio of axial position strands to bias carrier strands  
3 of at least 4:1.

1           9. A sleeve according to claim 3, wherein each said  
2 elastic thread is capable of being stretched to at least  
3 about 1.9 times its original length.

1           10. A sleeve according to claim 1, each of said first  
2 bias strands and each of said second bias strands having a  
3 braid angle of 45-75°.

1           11. A sleeve according to claim 9, said elastic  
2 thread being covered elastic thread.

1           12. A sleeve according to claim 1, said sleeve having  
2 a first axial position strand of a first material and a  
3 second axial position strand of a second material, said  
4 first material being different from said second material in  
5 type or weight.

1           13. A sleeve according to claim 12, said sleeve  
2 having a plurality of axial position strands, at least 10%  
3 of the axial position strands of the sleeve being of said  
4 first material, at least 40% of the axial position strands  
5 of the sleeve being of said second material.

1           14. A sleeve according to claim 13, at least 30% of  
2 the axial position strands of the sleeve being of said  
3 first material.

1           15. A method of making a triaxial braided sleeve  
2 comprising the steps of providing a regular braider having  
3 a full complement of carriers and having a plurality of

4 axial positions, providing each of a first set of carriers  
5 with elastic thread, said first set of carriers being not  
6 more than 1/4 of said full compliment of carriers,  
7 providing each of said plurality of axial positions with a  
8 reinforcement strand, and operating said braider to produce  
9 a triaxial braided sleeve having bias strands and axial  
10 reinforcement strands, each of said bias strands being an  
11 elastic thread.

1 16. A fiber-reinforced plastic part comprising a  
2 triaxial braided sleeve in a resin matrix, said sleeve  
3 comprising first bias strands extending in a first  
4 direction, second bias strands extending in a second  
5 direction, and axial reinforcement strands, all of the bias  
6 strands of the sleeve being in their natural state elastic  
7 strands.

1 17. A part according to claim 16, wherein said part  
2 is a tapered tube.

1 18. A part according to claim 16, wherein said part  
2 is a utility pole.

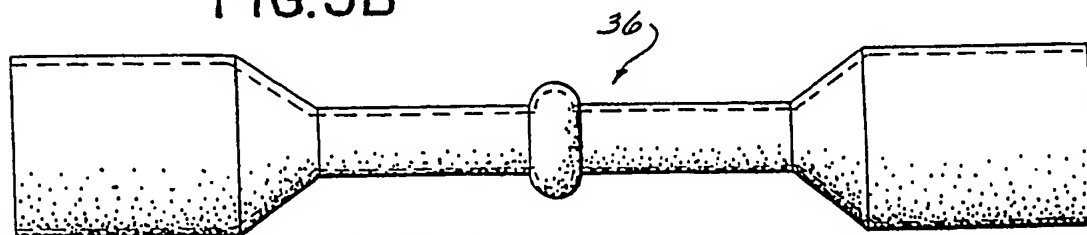
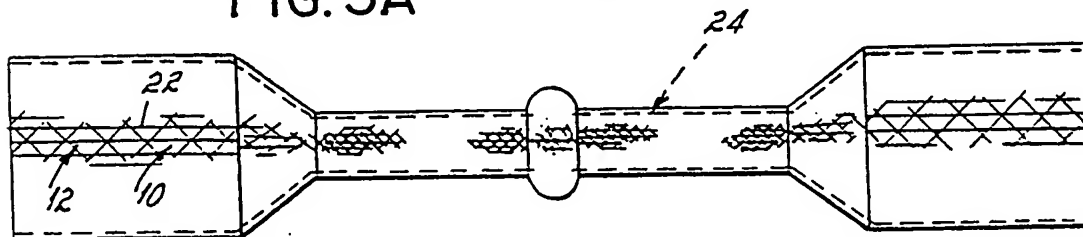
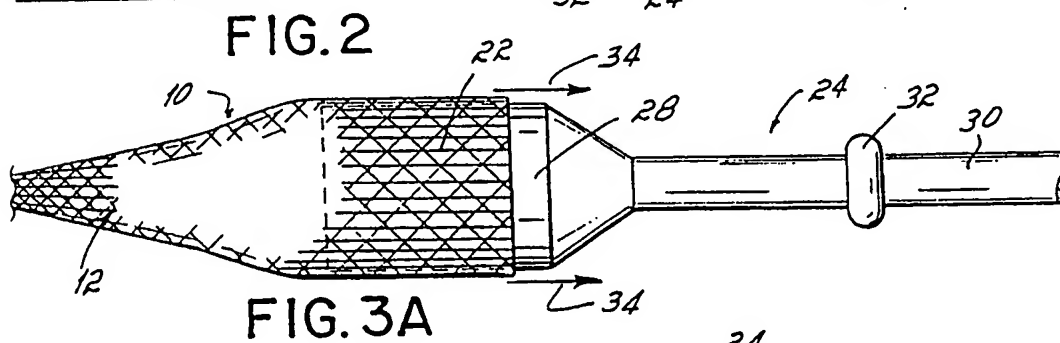
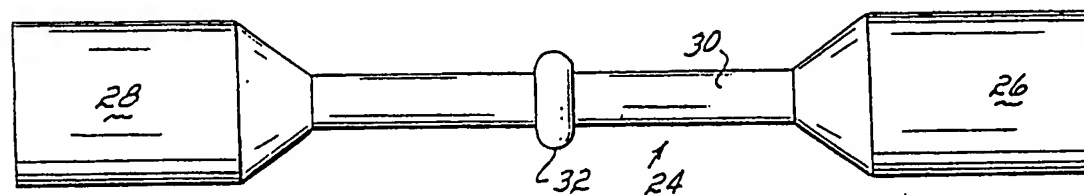
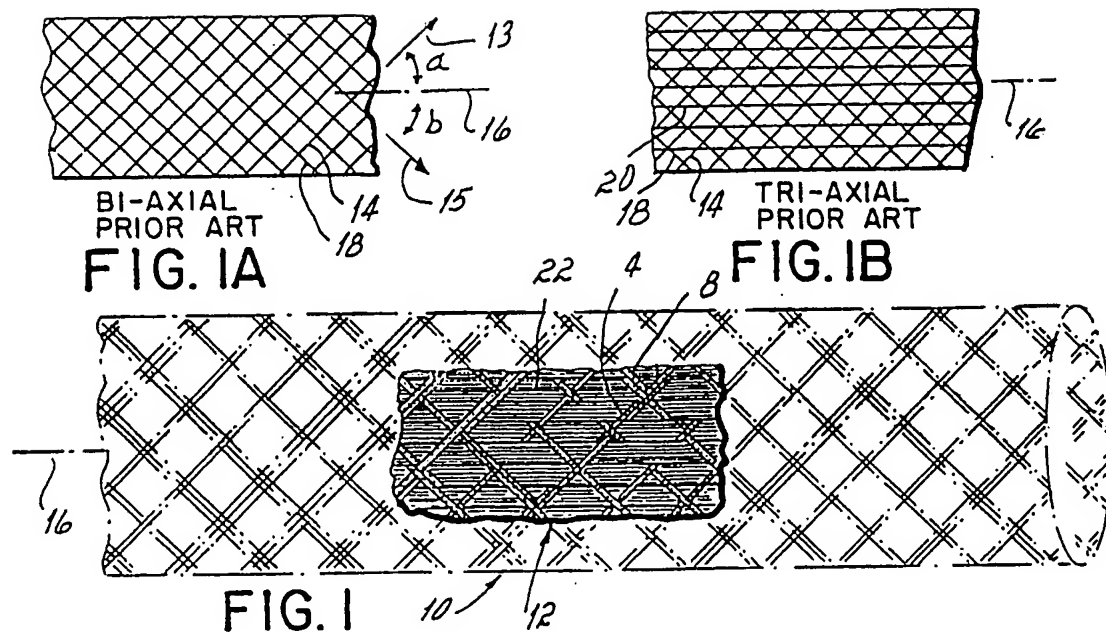


FIG. 4

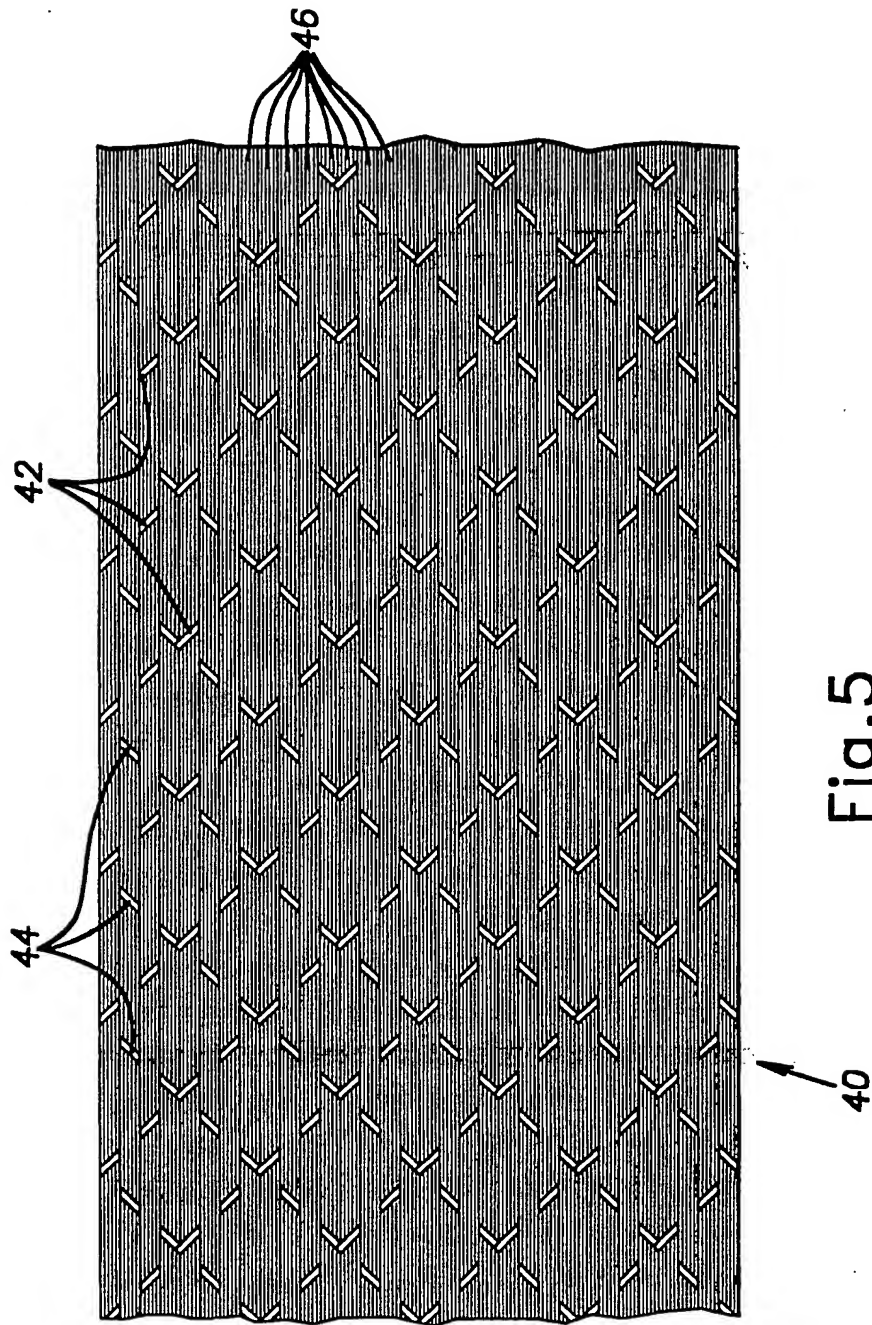


Fig. 5

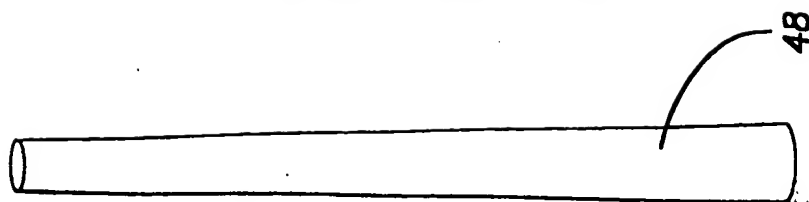


Fig. 6

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/21800

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B29D 23/00; D04C 1/02, 1/04

US CL :87/1, 2, 9; 428/34.5, 36.3, 36.9, 36.92

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 87/1, 2, 9; 428/34.5, 36.3, 36.9, 36.92

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

search terms: triaxial, braid?, elastic, elastomeric

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,834,755 A (SILVESTRINI et al.) 30 May 1989.	1
A	US 4,610,688 A (SILVESTRINI et al.) 09 September 1986.	1
A	US 4,533,321 A (KIDD et al.) 06 August 1985.	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search

25 MARCH 1998

Date of mailing of the international search report

13 APR 1998

Name and mailing address of the ISA/US  
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